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Baseline

Impingement of marine organisms in a tropical atomic power plant cooling water system

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ABSTRACT

A one-year impingement monitoring was conducted at Madras Atomic Power Station (MAPS), Kalpakkam, southeastern coast of India and identified a total of 67 species of marine organisms in the cooling water system. Estimates of total annual impingement contributed about 1.47×10^6 individuals and 142.5 t of biomass. Jellyfish contributed about 6.8×10^5 individuals and 135.6 t of biomass. Crabs, shrimps and fish were the most vulnerable organisms contributing about 4.29×10^5 individuals, 1.39×10^5 individuals and 2.16×10^5 individuals respectively. Commercially important species namely *Trichiurus lepturus*, *Sardinella longiceps* and *Portunus pelagicus* were found to be impinged 1.88% and 0.29% by number and weight of the total biomass respectively. Out of ~327 fish species recorded at Kalpakkam, only about 9.4% of species were impinged at MAPS. Multispecies impingement at MAPS poses the problem of finding the best mitigation options for tropical conditions.

Huge loss of marine organisms due to both impingement and entrainment is a major ecological concern related to power plant operation (Mayhew et al., 2000). While overall mortality in these processes is usually very high, definite adverse impacts on fish populations have been difficult to quantify (Lewis and Seegert, 2000). Mortality by impingement is widely variable and sometimes accounts in the order of tens of millions of fish annually (Saravanane et al., 1998; Greenwood, 2008; Azila and Chong, 2010). Moreover, organisms like gelatinous plankton, fishes, and crustaceans sucked into the cooling-water intake cause many operational malfunctions such as clogging of the filter screens, reduction of water flow in intake tunnel, silt deposition, condenser blockage etc. which ultimately affects the plant efficiency and power generation (Satpathy et al., 2010a). Though, entrainment and impingement studies are common from temperate regions, such studies in tropical power plants are rare. Owing to the action of multiple factors (water velocity, water temperature, salinity, materials used, mesh size of screens, temporal fluctuating parameters like tides, monsoon, day & night and biogeography), accurate quantification of entrained and impinged marine fauna and the relative impact on coastal ecology and economy is complex (Masilamani et al., 2002a; Heimbuch et al., 2007; King et al., 2010). Thus, long term study of entrainment and impingement phenomena in once-through cooling (OTC) power plants is required for appropriate quantification of faunal impacts.

Presently there are ten operating atomic power stations with OTC systems in India. Of these, four use river water and other six use sea water. In addition 5 power plants are either under construction or are being planned in coastal localities. Given the lack of knowledge on the impacts of power plant cooling water on coastal ecology in tropical countries like India, this study, the first of its kind, aimed at assessing the biotic losses caused by impingement in the CWS of Madras Atomic Power Station (MAPS), located near Kalpakkam, southeast coast of India, Bay of Bengal (Fig. 1). MAPS consists of two units of Pressurized Heavy Water Reactor (PHWR), each of 235 MW (e) capacity. Units I and II were commissioned in 1983 and 1985 respectively. MAPS operates with a once-through cooling (OTC) system and requires 35 $m^3 s^{-1}$ of cooling water (Satpathy, 1999; Masilamani et al., 2002b). After extracting heat, the heated seawater is subsequently released into the sea. The seawater is drawn through an underwater intake structure. The details of intake structure, pump house and functioning of the cooling water system of MAPS is described elsewhere (Satpathy et al., 1986; Satpathy and Nair, 1990). Considering the practical feasibility of obtaining samples, the present study was restricted to the Travelling Water Screen (TWS) location and thus only the impingement aspect is focussed here. The present study address the impingement at MAPS with respect to number of organisms, percentage of economically and commercially important species, and potential future loss in terms of biomass and number due to impingement. The study would be useful in enhancing the design and developmental features of CWSs for

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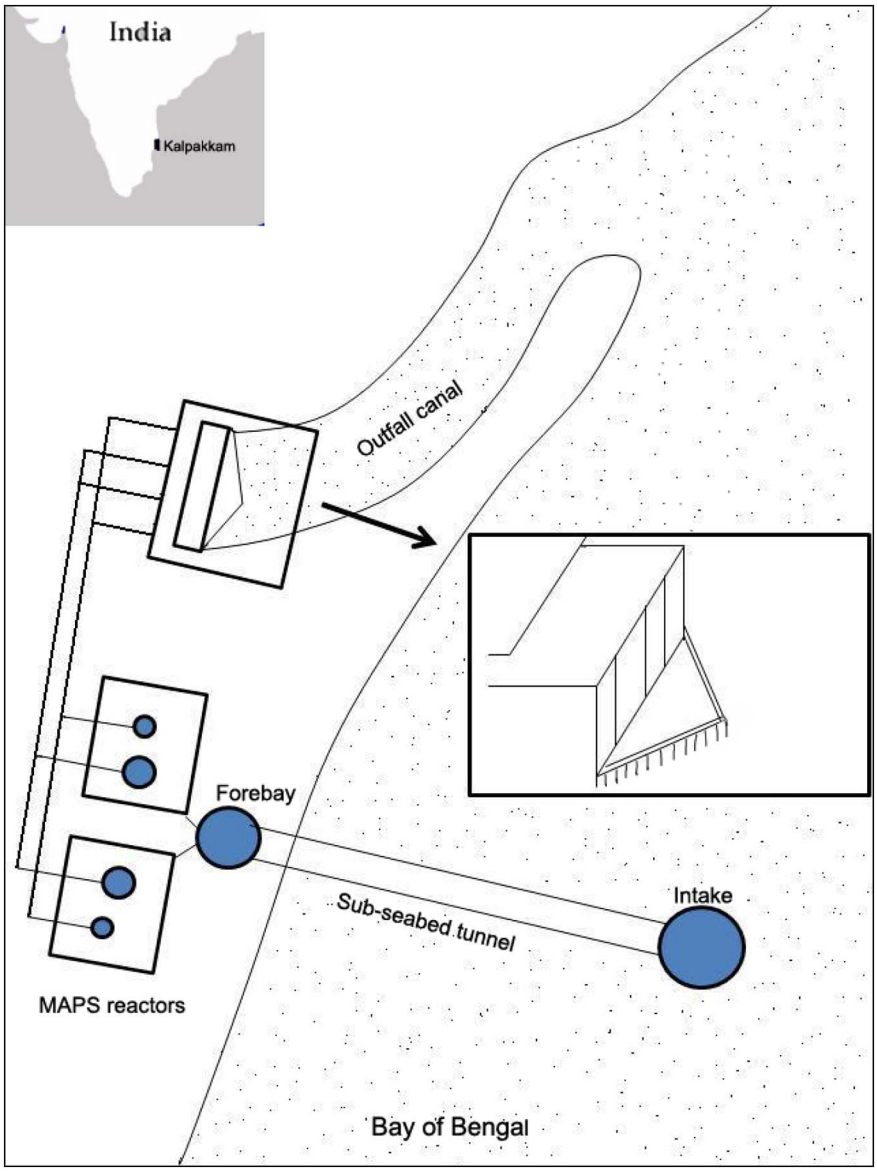

Fig. 1. Study area showing the schematic diagram of the cooling water intake of Madras Atomic Power Station, India.

upcoming power plants. It may also help addressing both ecological concerns as well as operational difficulties encountered due to impingement.

Samplings were carried out from March 2013 to March 2014 at TWS of MAPS pump house on a weekly basis. For this purpose, three TWS screens were monitored for one hour during each sampling effort according to their availability. The sampling was done on a weekly basis for day time and night time alternatively. This coast experiences semidiurnal tidal pattern with bi-annual change in current pattern (Satpathy et al., 2010b). Local tidal data was collected from tidal table (National Institute of Ocean Technology (NIOT) tidal table) and sampling was carried out during low and high tide conditions. Samplings for low and high tide were done alternatively once in two weeks. Samples were also collected on full moon day and new moon day to understand the effect of lunar cycle on impingement. The impinged organisms were identified on the spot and photographed, subsequently counted, weighed and catalogued in accordance with the sampling date and time. Each organism was noted for its condition as live, dead or wounded. The unidentified animals were photographed and then preserved with 10% buffered formalin for further identification with the help of published literature such as Day (1878), Munro (1982) and Talwar and Kacker (1984). The impinged species encountered were categorized according to their habitat namely rocky area or reef associated, demersal, benthic, pelagic-neritic, benthopelagic, pelagic and neritic. The impinged species were also categorized into commercial, highly commercial, minor commercial and low commercial value species. The habitat categorization and assessment of economic value of various species was performed based on FishBase (www.fishbase.org). Water quality parameters such as temperature, pH, salinity and dissolved oxygen (DO) were measured using a WTW – TOA DKK multi parameter probe. The heterogeneous group organisms impinged in the travelling water screen were grouped into five general faunal categories: fish, shrimp (including the mantis shrimps- Stomatopoda), crab, jellyfish and the residual group (mainly cephalopods and sea snakes). The estimates of annual impingement were calculated based on the use of 10 pumps (excluding 2 standbys) for 365 days. Average value of biomass and number of organisms for the 76 efforts was used for calculation of the annual loss of individuals and biomass. Species accumulation curve was plotted against sampling effort, for total number of species as well as for different groups such as fish, shrimp, crab, jellyfish, cephalopods etc. Analysis of variance (two-way ANOVA) was carried out to find out the variations in impingement pattern with respect to various temporal entities (high and low tide, time: day and night, different months). Agglomerative hierarchical clustering was